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SOME PHYSIOLOGICAL ASPECTS OF THE POTATO SCAB PROBLEM. II. CALCIUM AND CALCIUM-POTASSIUM RATIO[1]

G. V. C. Houghland and Lillian C. Cash[2]

Two factors appear to be of primary importance in the development of scab, *Streptomyces scabies*, in potato land and its subsequent effect on the crop. These are, the organism's soil environment, and its ability to infect the tuber. Soil acidity is undoubtedly the chief environmental factor, and it may well be that the occurrence of scab when the soil reaction is around pH 4.8, where it ordinarily would not be expected, is caused by acid-resistant strains of the organism. Once growth has started, it is entirely possible that the growing organism may alter the reaction in its immediate environment sufficiently to establish localized infestations. Houghland and Cash (4) found that the growing scab organism was able to effect a pronounced increase in the pH of its culture medium and Jones (7) and Sanford (11) likewise noted an increase in the alkalinity of the medium supporting scab growth. The acidity aspect of the scab problem was more fully discussed in a previous publication (4). The present paper presents the results of an investigation to determine the relations of calcium and the calcium-potassium ratio of the potato plant to tuber infection by the scab organism.

Calcium

Acid potato soils are generally low in calcium, and this condition, according to Horsfall *et al.* (5), causes a deficiency of calcium in the potato plant which accordingly accounts for the failure of the scab organism to infect tubers grown on acid soils. Hydrogen-ion *per se* is not considered by them to be toxic to the scab organism, but calcium is considered directly or indirectly essential for tuber infection. A similar nutritional theory of scab infection was advanced by Schroeder and Albrecht (12) who included potassium as well as calcium. They concluded that a 1 to 1 ratio of calcium to potassium in the soil and in the potato vines was highly important in preventing scab infection and did not consider a liberal supply of calcium scab-provoking.

Both of these theories seem to place undue emphasis on the calcium needs of the scab organism not apparent from its growth requirements. Good growth of the organism was obtained by Houghland and Cash (4) in practically every case where no calcium, except the small amount contained in the potato extract, was added to potato-dextrose agar. *Streptomyces scabies* will grow very well also on Richards' and Czapek's solutions, neither of which contains any added calcium. The reaction of these media is generally adjusted to a pH 7.0 with NaOH, but calcium need not be added to get good growth.

Since it is in the periderm of the infected tuber that active growth of the scab organism usually takes place, it would seem from the foregoing theories that the calcium and potassium concentrations in this region of scabby and clean potatoes should have special significance. Accordingly

[1]Accepted for publication December 20, 1955.
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samples of scabby, scurfy, and clean tubers were selected from a crop of Katahdin potatoes grown on a field infested with the scab organism. These were thoroughly washed and so peeled as to obtain all of the periderm tissue and as little of the cortex as possible. The peeling samples were designated "periderm". Samples composed of the remainder of the tubers, including some of the cortex and all of the medullary were designated "medullary". The periderm and medullary tissues were then oven-dried and analyzed for phosphorus, potassium, and calcium. The results of these analyses are given in table 1. In general, greater differences in composition occurred in the periderm than in the medullary tissues. It is noteworthy that the periderm of the scabby tubers contained almost twice as much calcium as that of the clean tubers. The significance of the higher calcium content of the scabby-tuber periderm is not clear at present. It might be regarded as a factor predisposing the tubers to infection or as a result of infection due to a build up of sap under the corky scab lesions similar to that shown by Priestley and Woffendon (10), after the formation of wound cork.

TABLE 1.—*Analyses of periderm and medullary tissues of Katahdin potatoes from a scab-infested field expressed as mgs. per 100 gms. of dry tissue.*

Kind of Tubers	Phosphorus		Potassium		Calcium	
	Periderm	Medullary	Periderm	Medullary	Periderm	Medullary
Clean	266	296	2,710	2,110	96	45
Scurfy	343	322	2,883	2,071	123	43
Scabby	409	325	2,562	2,044	184	41

Since calcium is not a growth requirement of *Streptomyces scabies*, which is known to grow freely in the middle lamella (7, 9) and on pectin from several sources (9), it would seem reasonable to assume that the role of calcium in the periderm of infected tubers is one of counteracting adverse pH conditions during enzymatic action on the middle lamella protopectins. However, a test for pectin-methylesterase, outlined by Kertesz (8), failed to demonstrate the presence of the enzyme produced by *Streptomyces scabies* in the periderm tissue of scabby potatoes and in the substrate of a culture of the scab organism. Therefore the theory of Priestley and Woffenden (10) assuming a build-up of sap in the periderm following wound cork formation seems to offer a plausible explanation for the increase in calcium in the periderm of the scab-infected tubers.

Support for this assumption will be noted in table 1 where the calcium concentration in the periderm and medullary of the three kinds of tubers show an inverse relationship. Since the medullary contained more than 70 per cent of the total dry matter in the tubers, the significance of the differences in medullary calcium is greatly increased. From the standpoint of the sap build-up theory of Priestley and Woffenden (10) the increase of periderm calcium in the scabby tubers appears to be a result of infection rather than a predisposing factor. In this connection, it should be noted that the scurfy tubers were intermediate in periderm calcium content. Phosphorus also was found to vary in the periderm of the three kinds of

tubers in the same order as calcium, but the relative differences were smaller. The differences in potassium, however, were relatively small compared with those obtained for calcium and phosphorus.

Calcium-Potassium Ratio

The relative amounts of calcium and potassium in potato vines and their translocation to the tubers present certain interesting features related to the calcium-potassium theory of scab infection suggested by Schroeder and Albrecht (12). Since scab infection takes place some time during the early development of the tuber (11), the relative translocation rates of calcium and potassium have a direct bearing on the ratio of these two elements in the tubers at time of infection and during subsequent scab development. A study of the curves presented in figure 1 shows that at no time during the growing season was there a 1 to 1 ratio of calcium to

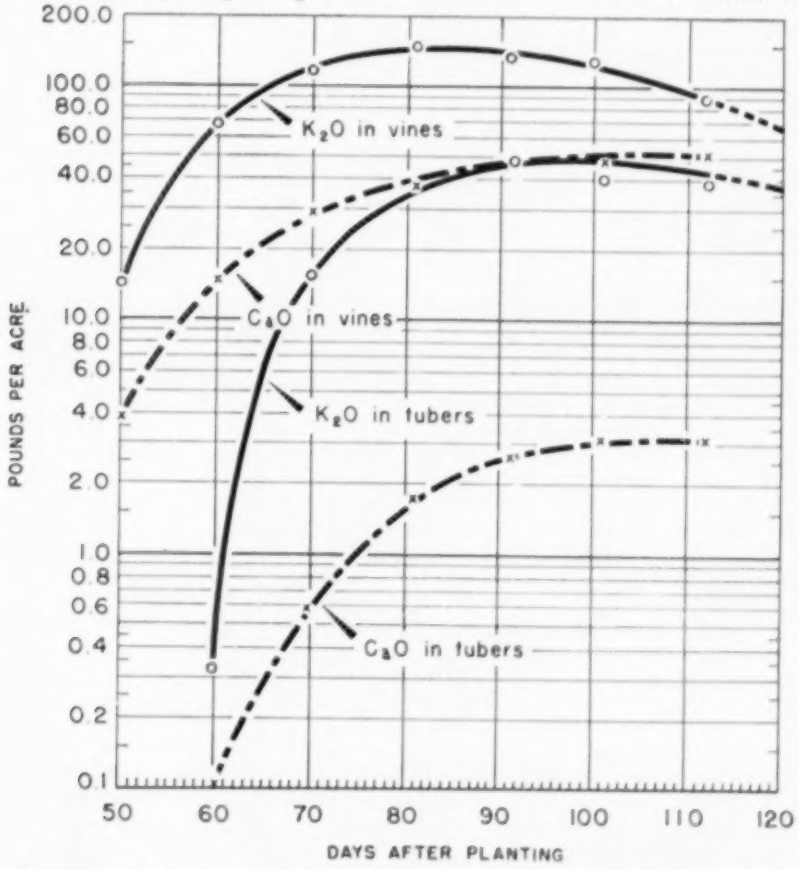

Figure 1.—Calcium and potassium contents of potato vines and tubers at 10-day intervals throughout the growing season, after Hawkins (1).

potassium in the vines or tubers, as suggested by Schroeder and Albrecht (12) as a preventive to scab infection. The fertilizer used by Hawkins (1) in his studies was a 4-8-8 mixture, containing ample calcium and magnesium, applied at 2,500 pounds per acre.

Because of the marked differences in the translocation of calcium and potassium it is highly unlikely that a 1 to 1 ratio of calcium to potassium will ever be found in potato tubers. James (6), after making a thorough study of the distribution of potassium in the potato plant, concluded that the leaves lose potassium to the stems and the stems lose it to the tubers very rapidly as maturity approaches. Calcium, on the other hand, is poorly translocated, probably because much of it is rendered insoluble as organic salts. This differential translocation of calcium and potassium throws considerable doubt on the soundness of a scab resistance theory based on a 1 to 1 ratio of calcium to potassium.

Experimental Procedure

In making studies of the nutrition of potatoes in relation to their scab susceptibility in soil or sand it is apparent at the outset that variations in the nutrients supplied the plant can affect also the growth of the scab organism. Failure to infect could be due to an environment unfavorable for growth of the causal organism or to the resistance of the plant; therefore these effects are ordinarily confounded. However, it was possible to separate these effects by using a specially designed solution-culture apparatus in a greenhouse experiment conducted to determine the relation of the calcium-potassium ratio to tuber susceptibility to scab. Each solution-culture unit consisted of a plant nutrient reservoir and an entirely separate compartment containing a scab-infested medium in which the tubers developed. The solution-culture apparatus and procedure have been described in detail elsewhere (2, 3), and only the treatments and results of the experiment are given here.

Each experimental unit consisted of one potato plant of the Green Mountain variety, and the individual treatments were replicated 4 times. The potato seedpieces were sprouted in sand, and the plants when about 4 inches high, minus the seedpieces, were transferred to the solution cultures. Eight days later vermiculite infested with *Streptomyces scabies* was added to each tuber compartment where it would be in contact with the developing tubers but completely separated from the nutrient solutions. The nutrient solutions used were based on a formula known to give good growth of potatoes and these were altered by adding calcium chloride, potassium chloride, or both, to provide the various Ca-K ratios. The solutions were renewed every 2 weeks and were aerated continuously.

Results

The results of the experiment, after the plants had grown 86 days, including the analyses of vines and tubers are given in table 2. From these analyses it is appparent that the concentrations of calcium and potassium in the vines differed markedly from those in the tubers. The calcium in the minus-calcium plants undoubtedly came from the seedpieces, the sand in which they were sprouted, and the small amount in the tap water—less

TABLE 2.—*Scab susceptibility of tubers of Green Mountain variety of potato as affected by altering the calcium and potassium contents of vines and tubers.*

Nutrient Solutions		Yields			Vines			Tubers		
Ca-K Ratio p.p.m.	pH	Dry Weight of Tops (Total 4 Replications)	Fresh Weight of Tubers (Total 4 Replications)	Scabby Tubers	Ca	K	Ca-K Ratio	Ca	K	Ca-K Ratio
		Gm.	Gm.	Pct.	*Mg.	*Mg.		*Mg.	*Mg.	
0-60	6.3	17.5	262	96.0	899	5,958	1-7	24	2,064	1-86
66-60	6.3	25.5	299	99.3	2,094	6,110	1-3	40	1,995	1-50
133-60	6.1	22.7	278	100.0	2,424	6,179	1-3	71	1,933	1-27
120-34	6.2	25.7	373	91.0	2,669	1,228	2-1	37	1,746	1-47
120-67	6.3	46.1	770	100.0	2,881	2,185	1-1	49	1,808	1-37
120-133	6.3	34.1	423	100.0	2,309	4,998	1-2	56	2,150	1-38

*Mgs. per 100 gms. of dry tissue. Chemical methods: Calcium by official calcium oxalate method; potassium by Wilcox cobalt initrite method.

than 10 p.p.m. Potato plants grown entirely without calcium in the nutrient solution produce neither vines nor tubers that are normal.

The amount and severity of scab (Figure 2 and table 2) at all the Ca-K ratios used indicate clearly that the ratio of these two elements in the vines and tubers had no effect on tuber susceptibility. Analyses of the tubers also show that a 1 to 1 ratio of calcium to potassium was not obtained in a single case. Moreover, the Ca-K ratio in the vines had no apparent relation to the same ratio in the tubers or their scab susceptibility.

The ratio of calcium to potassium in the nutrient solutions of the second and last treatments in table 2, was approximately 1 to 1 but the ratios obtained in the vines were respectively 1-3 and 1-2, and in the

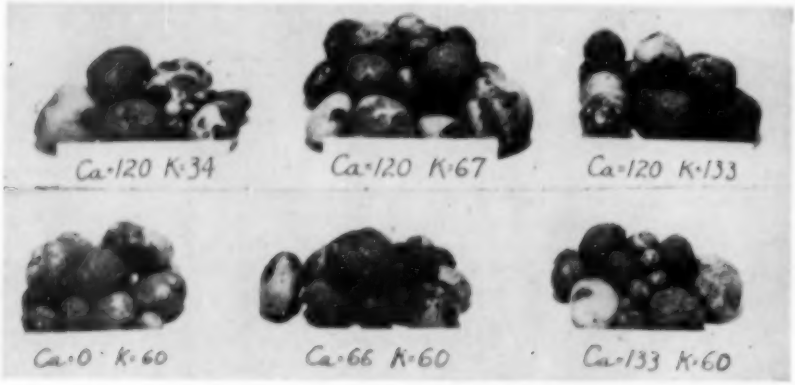

FIGURE 2.—Scab infection on Green Mountain potato tubers grown with nutrient solutions having different Ca-K ratios.

tubers 1-50 and 1-38. Hawkins (1) obtained comparable ratios of 1-5 for vines and 1-33 for tubers at 80 days, and 1-2 for vines and 1-42 for tubers at harvest, 112 days.

The first 3 nutrient ratios listed in table 2 produced vines considerable higher in potassium, it will be noted, than the last 2 ratios, although the latter solutions contained as much or more potassium. In seeking an explanation for these differences it should be noted that tuber production was much greater with the last 2 ratios than with the first 3. Apparently there was a greater translocation of potassium from vines to tubers where more potatoes were produced.

SUMMARY AND CONCLUSIONS

An experiment was conducted in the greenhouse to study the relation between the calcium-potassium ratio of nutrients supplied potatoes and their susceptibility to scab. A specially designed solution-culture apparatus which provided inoculum in a completely separate tuber compartment was used.

At the termination of the experiment the ashed vines and tubers were analyzed for calcium and potassium. The percentages of scabby tubers obtained under the experimental conditions indicated clearly that the

calcium-potassium ratio in the vines and tubers had no effect on tuber susceptibility to scab. There was also no indication of a relation between the total calcium content of the tubers and their scab susceptibility. Because of the differences in the amounts of calcium and potassium translocated from vines to tubers, the ratio of these two elements in the tubers in no case was found to be 1 to 1 and it seems highly unlikely that this ratio will ever be found in potato tubers.

The calcium content of the periderm of scabby potatoes was found to be practically twice that of clean tubers, whereas the calcium content of the periderm of scurfy tubers was intermediate. Phosphorus in the periderm of the three kinds of tubers also followed a trend similar to that for calcium, but the relative differences were not as great. The potassium concentrations in the periderm and medullary of clean, scurfy, and scabby potatoes, however, showed relatively small differences compared with those for calcium and phosphorus.

It was suggested that the increased concentration of calcium in the periderm of the scabby potatoes was a result of infection and not a predisposing factor. A possible relation between calcium and enzyme action produced by the scab organism on the protopectins of the middle lamella was considered unlikely since pectin-methylesterase was not demonstrated to be produced by the organism in scabby potato tissue or in the substrate of a culture of *Streptomyces scabies*.

Literature Cited

1. Hawkins, Arthur. 1946. Rate of absorption and translocation of mineral nutrients by potatoes in Aroostook County, Maine, and their relation to fertilizer practices. Jour. Amer. Soc. Agron. 38: 667-681.
2. Houghland, G. V. C. 1950. An improved technique for growing potatoes in solution cultures. Amer. Potato Jour. 27: 257-262.
3. ———— and Cash, Lillian C. 1954. The use of vermiculite in providing scab inoculations for potatoes. Pl. Dis. Reptr. 38: 460-461.
4. ———— and ————. 1955. Some physiological aspects of the potato scab problem. I. Acidity and aluminum. Amer. Potato Jour. 33: 86-91.
5. Horsfall, James S., John B. Hollis, and H. G. M. Jacobson. 1954. Calcium and potato scab. Phytopath. 44: 19-24.
6. James, W. O. 1931. Studies on the physiological importance of the mineral elements in plants. II. Potassium; its distribution, movement, and relation to growth in the potato. Ann. Bot. 65: 425-442.
7. Jones, A. P. 1931. The histogeny of potato scab. Ann. Appl. Biol. 18: 313-333.
8. Kertesz, Z. I. 1951. The pectin substances. Interscience Publishers, Inc., N. Y.
9. Lutman, B. F. 1941. Actinomyces in potato tubers. Phytopath. 31: 702-712.
10. Priestley, J. H. and L. M. Woffenden. 1922. Physiological studies in plant anatomy. V. Causal factors in cork formation. New Phyt. 21: 252-268.
11. Sanford, G. B. 1926. Some factors affecting the pathogenicity of *Actinomyces scabies*. Phytopath. 16: 525-547.
12. Schroeder, R. A. and W. A. Albrecht. 1952. Plant nutrition and the hydrogen-ion. II. Potato scab. Soil Sci. 53: 481-488.

GROWTH RESPONSE FROM RESTRICTING THE OXYGEN AT ROOTS OF YOUNG POTATO PLANTS[1]

JOHN BUSHNELL[2]

Field experiments in Ohio have demonstrated that potatoes thrive best on soils of exceptional porosity (*2*). Supplementing the field studies, pot experiments showed that the potato roots,—or the underground parts as a whole,—absorb oxygen in surprisingly large amounts. The present study aimed to determine if restricting the oxygen available to the roots retards growth and if distinctive symptoms of deficiency appear. In the field, following midsummer compaction of silt loam by heavy rain, growth gradually ceases, and the tops slowly die down much the same as they do from severe drought (*2*). For the present study, plants were grown in gravel cultures sealed off at the surface so that oxygen could be restricted without compaction or other physical interference with the functioning or growth of the roots.

The details of procedure in growing the plants were given in the preceding contribution.[*] In brief, Irish Cobbler plants were grown in three-gallon jars filled with slag, sealed off at the surface with pliable paraffin, each jar connected with a large bottle of nutrient solution and one of air mixture, as illustrated in figure 1.. After each irrigation with nutrient solution, air mixture was allowed to flow into each jar.

The experiments were conducted during April when good sunlight and low temperatures favorable for potatoes could be obtained in a greenhouse. Started when the plants were 8 to 10 inches tall and stolons were forming, the treatments were discontinued when the development of tubers began to bulge the paraffine cover, a period of less than two weeks.

For the first experiment, bottles of air were diluted with nitrogen to give mixtures of 5, 10, 15, and 20 per cent of oxygen. Each mixture was given to one plant, and a fifth plant without a paraffine seal was included as a check. Fresh gas mixtures were supplied only at the outset. Thereafter the initial oxygen content was maintained by daily analysis of the gas in each reservoir bottle and the addition of measured amounts of oxygen. The chemical removal of accumulated carbon dioxide was found unnecessary; it diffused out through rubber tubing used for connections.

In planning the experiment, it was presumed that the gas mixtures flowing to the roots after daily irrigation would supply more oxygen than the roots would use. With a volume of approximately 4 liters of gas flowing to each jar, the oxygen supplied by the mixture with only 5 per cent was found at the outset to be almost entirely consumed. And as the plants developed, the larger proportion of oxygen available to other plants was similarly absorbed. The experiment thus became a test of restricting the oxygen supply to the roots, not simply a test of maximum concentration available.

During the 12 days of treatment the plants grew exceptionally well, developing handsome flower racemes, as shown in figure 1. Effects of the treatments pictured in figures 2 and 3, and summarized in table 1, show

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Journal Article No. 62-55, Ohio Agricultural Experiment Station, Wooster, Ohio.
[2] Associate Professor, Department of Horticulture.
[*] American Potato Journal 33: 203-210.

FIGURE 1.—Arrangement of Experiment 1. Tilted bottles contain air mixtures; upright ones, nutrient solutions. Labels refer to percentage of oxygen in the air mixtures.

that the restriction of oxygen conspicuously affected the growth of tubers, not simply retarding their growth but inducing abnormal shapes at the two low oxygen treatments. Less conspicuous was the effect on leaflets, their growth being roughly proportional to the amount of oxygen supplied to the roots. Noticeable retardation of growth of stems occurred only at the 5 per cent treatment. Most surprising was an increase in branching at the 10 and the 15 per cent oxygen treatments. Restricting the oxygen supply to the roots also induced an increase in the percentage of dry matter in the tops.

Experiment 2 was narrowed to a test of normal air compared to a dilution containing three-fourths normal oxygen. Fresh gas mixture was supplied daily, using the greenhouse air, found to average 20.4 per cent of oxygen. No determination was made of the oxygen consumed. Instead, the carbon dioxide respired was measured daily,—the rubber tubing being replaced where needed with glass connections. Record was also kept of nutrient solution absorbed.

Special care was taken at the outset to select pairs of plants similar in size and growing at the same rate. Thus at the outset plant A was

FIGURE 2.—Plants of Experiment 1 on eleventh day of treatment. Labels show percentage of oxygen in the air mixture supplied to roots.

TABLE 1.—*Growth data from plants of Experiment 1.*

Treatments started April 18,—terminated May 2, 1945.

Oxygen in gas mixture supplied to roots, approximate per cent	20	20	15	10	5
Approximate volume of oxygen available daily to roots, ml.	*	880	†	365	205
Average daily absorption of oxygen, ml.		608	†	365	205
Growth and Weight Measurements					
Main stem, increase in length, Apr. 18-30, cm.	18.5	15.0	17.5	15.0	10.5
All branches, total increase in length, cm.	74.0	54.0	96.5	88.2	49.5
Terminal leaflets, average increase in width:					
On leaves at nodes 7-9					
Preceding treatment, Apr. 14-18, mm.	7.7	5.3	5.0	6.3	6.7
During treatment, Apr. 18-28, mm.	15.3	11.7	6.0	6.4	4.0
On leaves at nodes 11-13, Apr. 21-May 1, mm.	20.7	15.0	10.3	6.6	4.0
Fresh weight, May 2					
Stems and leaves, gm.	369	315	399	390	292
Tubers and stolons, gm.	146	90	47	40	11
Dry weight					
Stems and leaves, gm.	41.2	41.0	50.8	54.3	48.0
Tubers and stolons, gm.	17.5	11.7	6.1	5.6	1.8
Roots, gm.	4.5	3.3	3.25	4.4	4.7
Total	63.2	56.0	60.15	64.3	54.5
Dry matter in tops, per cent of fresh weight	11.2	13.0	12.7	13.9	16.4

*No surface seal.

†Very small leak through paraffine at the stem could not be stopped. Presumably some of the oxygen absorbed by the roots leaked in; daily addition averaged only 306 mls.

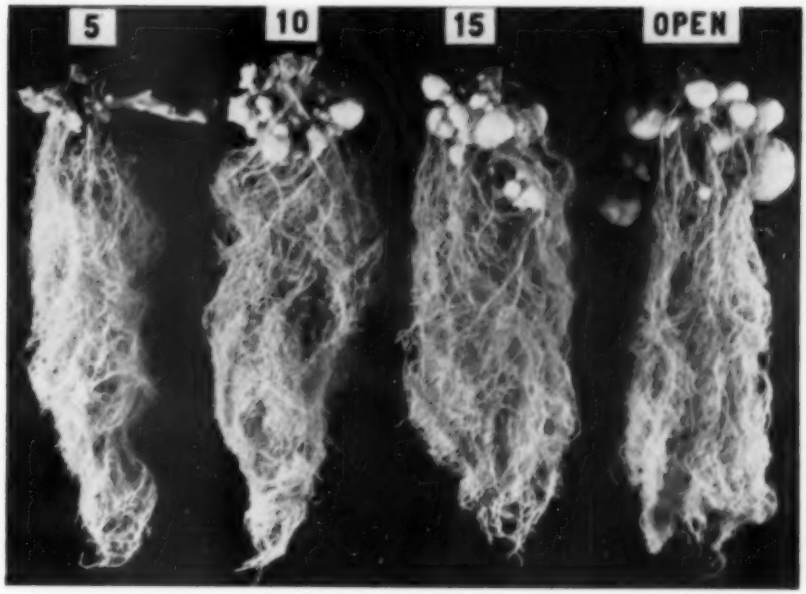

FIGURE 3.—Effects of oxygen concentration on roots and tubers in Experiment 1. Labels show percentages of oxygen.

judged the same size as B, and plant C was paired with D. The results after 12 days of treatment are pictured in figure 4, and the measurements and weights given in table 2.

In agreement with Experiment 1, supplying air with about 15 per cent of oxygen induced a conspicuous increase in development of branches. Also in good agreement, the growth of younger leaflets was retarded, and the dry matter content of the tops as a whole increased. Although the tubers were considerably smaller on one of the check plants than on the other, they were larger than on either of the plants grown at the reduced oxygen treatment. As an average, the 15 per cent oxygen treatment reduced tuber growth about 70 per cent. In Experiment 1, the reduction was 48 per cent.

In view of the differences in growth due to the treatment, it was surprising to find no appreciable difference in the volume of carbon dioxide respired under the paraffine seal, or in the amount of nutrient solution absorbed.

DISCUSSION

From a practical viewpoint the results are of interest, first because they demonstrate that a marked reduction in growth of tubers may be induced by relatively moderate reduction in the oxygen available to the

TABLE 2.—*Growth data from plants of Experiment 2.*

Treatments started March 22, terminated April 3, 1946.

Plant designation in figure 4.	A	D	B	C
Gas mixture to roots, per cent of air:	100	100	75	75
Oxygen content at beginning of daily run, %	20.4	20.4	15.3	15.3
At end of run, average daily %*	12.7	12.8	7.8	8.0
Growth and Weight Measurements				
Main stem, increase in length in 12 days, cm.	22.0	21.0	16.5	17.5
All branches, total increase in length, 12 days, cm.	35.0	37.0	60.0	58.0
Terminal leaflets, aver. increase in width				
At nodes 4 through 9, March 22-27, mm.	12.4	12.0	10.4	13.4
At nodes 6 through 11, March 27-31, mm.	5.6	6.2	4.4	4.8
Fresh weight, Apr. 3				
Stems and leaves, gm.	191	188	190	206
Tubers and stolons, gm.	30.0	10.5	4.8	7.0
Dry weight				
Stems and leaves	16.2	16.0	19.9	21.2
Tubers and stolons	4.9	1.7	0.7	1.2
Roots	3.6	4.0	3.5	3.9
Total	24.7	21.7	24.2	26.3
Dry matter in tops, per cent.	8.5	8.5	10.5	10.3
Daily absorption of nutrient solution, average, ml.	222	238	226	232
Carbon dioxide respired under seal, daily average mgm.	407	405	398	389

*Calculated from percentage of carbon dioxide present.

FIGURE 4.—Plants of Experiment 2 on eleventh day of treatment. All jars have paraffine seals on surface. Numbers on jars are percentage of oxygen maintained by measured amounts added daily to each jar.

roots and tubers. Second, such deficiency may be present for twelve days with only an increase in branching to be noted as a symptom above ground.

No effort was made in this brief study to determine whether the marked effects on the tubers were due primarily to the restriction of oxygen supply for the roots, or to the reduced tension of the oxygen surrounding the tubers themselves. That the abnormal development of the tubers may be directly due to deficiency of surrounding oxygen is suggested by a study of Naka in Japan (7). Depriving young growing tubers of oxygen, he found their respiration reduced, and as respirable sugars accumulated, some of the undeveloped buds grew into sprout-tubers. The fact that abnormality was more pronounced in the pot studies here than the writers have observed in the field, and that tubers in the field, being shallow, are likely to be better aerated, tends to support the hypothesis that deficiency of oxygen at the tuber itself induced the abnormalities.

No other reports dealing directly with oxygen supply to potato roots or growing tubers have been found in the literature. From numerous studies with other plants, however, the generalization has been drawn that oxygen deficiency at the roots retards absorption of water (Kramer, 6). Absorption of nutrients may also be retarded as found with tomatoes by Arnon and Hoagland (1).

Contrary to expectation, the plants of Experiment 2, supplied with gas-mixture of 15.3 per cent oxygen absorbed as much nutrient solution as those supplied with normal air (20.4 per cent oxygen). At the same time the tops had a higher content of dry matter while the tubers were smaller, suggesting some interference of translocation of organic materials from the tops to the tubers. Interference with translocation of sugars was found to be associated with potassium deficiency by Watson (8). Hence, the reduction of oxygen at the roots may have impeded absorption of potassium which in turn impeded translocation. These interferences are mentioned merely to show wherein the data at hand agree with current physiological concepts. The point of importance for the present study of symptomology is that a marked difference in growth of branches and tubers occurred while the water intake by the plants was not appreciably affected.

In the literature above mentioned were found several comparisons of the sensitivity of two or more kinds of plants. Of the plants studies, the tomato has been rated as most sensitive to aeration of its roots. (Hopkins *et al.* 4, Gilbert and Shive, 3). It is of interest, then, that restriction of oxygen to tomato roots has been reported to retard the growth of leaves and stems to about the same degree as it affected the potato plants here, but branching of tomatoes was not stimulated. Tomato roots proved more sensitive than found here for potato roots, but no part of the tomato plant was as conspicuously affected as were the tubers in the present study.

Summary

Two tests were conducted with four pots each of Irish Cobbler potatoes in gravel culture to observe the growth response from supplying their roots with air mixtures containing less than normal proportion of oxygen. Treatments were restricted to the short period of growth extend-

ing from the time the seed pieces could be removed to the time the new tubers became large enough to bulge up the paraffine layer used for surface seal on the gravel.

In both tests the growth response to air with three-fourths normal oxygen (15 per cent) was a conspicuous increase in the development of above ground-branches, and some reduction in the growth of the tubers.

Only one test was made with air mixtures reduced to one-half and to one-fourth of normal oxygen. Under these treatments the young tubers became abnormal in shape. The tops were not conspicuously affected.

Treatment with three-fourths normal oxygen did not appreciably affect the amount of nutrient solution absorbed by the roots, or the amount of carbon dioxide respired by the underseal parts of the plants.

Literature Cited

1. Arnon, D. I. and D. R. Hoagland. 1940. Crop production in artificial culture solutions and in soil with special reference to factors influencing yields and absorption of inorganic nutrients. Soil Sci. 50: 463-485.
2. Busnell, John. 1953. Sensitivity of potatoes to soil porosity. Ohio Agr. Exp. Sta. Res. Bull. 726.
3. Gilbert, S. G. and J. W. Shive. 1942. The significance of oxygen in nutrient substrate for plants. I. The oxygen requirement. Soil Sci. 53: 143-152
4. Hopkins, H. T., A.W. Specht and S. B. Hendricks. 1950. Growth and nutrient accumulation as controlled by oxygen supply to plant roots. Plant Physiol. 25: 193-209.
5. Kramer, Paul J. 1940. Causes of decreased absorption of water by plants in poorly aerated media. Amer. Jour. Bot. 5: 312-220.
6. ————. 1949. Plant and soil water relationships. McGraw-Hill Co., New York.
7. Naka, J. 1950. Physiological and ecological studies on potato plants. III. Investigation on the secondary growth of potato tubers, expecially in relation to air components in soil. Kagawa Agr. College. Tech. Bull. 2: 9-21. (Japanese,—with English summary.)
8. Watson, D. J. 1936. The effect of potasium chloride on the diurnal changes of the carbohydrates of the potato leaf. Ann. Bot. 50: 59-83.

THE RESISTANCE OF POTATO VARIETIES TO STORAGE DECAY CAUSED BY FUSARIUM SAMBUCINUM f. 6 AND FUSARIUM COERULEUM[1]

G. W. AYERS[2]

INTRODUCTION

Potato breeding for resistance to late blight, virus diseases and common scab has resulted in the appearance of a number of new varieties that possess outstanding horticultural and disease-resistant characteristics. It has been noted, however, that newly released stocks may show extreme susceptibility to diseases, not general in occurrence, but which may cause serious losses in some areas. Fusarium storage decay of potatoes may be considered one of these diseases. Losses have been sustained in Alberta and British Columbia and in the Maritime Provinces.

The data presented in this paper deal with varietal resistance to tuber decay caused by the dry-rot pathogens, *Fusarium sambucinum* f. 6 and *Fusarium coeruleum*. Progress of decay has been calculated as rot indices for promising seedling stocks and for varieties already in commercial production.

It is believed that resistance shown in certain stocks may prove useful in breeding for resistance. Where high susceptibility has been shown in established varieties steps must be taken to minimize the occurrence of decay.

MATERIALS AND METHODS

Varieties and seedlings under test for resistance to storage rot at Charlottetown were secured from the potato breeding station at Fredericton, New Brunswick, and from Aroostook Farms, Presque Isle, Maine. All stocks received since the initiation of the program in 1949 were grown at Charlottetown for a period of at least two years, during which time an assessment was made of their resistance to Fusarium tuber decay.

The technique of inoculation as described by Ayers and Robinson (1) was employed during each year of experimentation and the various steps are briefly summarized as follows: Before inoculation tubers were thoroughly washed in order to remove possible sources of contamination. Infection courts were established by using a block having three closely grouped protruding nails designed to inflict tuber injury to a depth of 2.4 centimeters. Triple punctures made with this wounding device were regarded as a single court of infection whether or not rot became established in one or more of the wounds. Two such compound infection courts were prepared in each tuber before the tubers were immersed in spore suspensions of the desired concentrations. The density of spore suspensions was measured with a haemacytometer and varietal suscepti-

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bility comparisons were made on the basis of constant spore density in the immersion media. Varieties were treated in replicates of four, each containing 20 tubers. The immersion medium was renewed after the treatment of each varietal replicate and the tubers were then placed in open mesh sacks. After being dried at room temperature for 24 hours the potatoes were stored at 40-45° F. Examination for extent of decay was undertaken after four to five months' storage by slicing the tubers at right angles to the line of the wounds and at approximately half their depth. The severity of rot was then calculated by giving each lesion a rating of 0 to 6 to denote the extent of the rotted area. Figures obtained were weighed and converted to a percentage called the "rot index" by the following computation:

$$\frac{\text{sum of ratings} \times 100}{\text{number of inoculations} \times 6}$$

Preliminary Trials 1949-1951

Early trials using varied techniques of wounding and inoculation, indicated that the common named potato varieties differed widely in susceptibility to the tuber rotting organism *Fusarium sambucinum* f. 6. High susceptibility was noted in Sebago, Sequoia, and Chippewa but Irish Cobbler and Warba showed moderate resistance.

Results 1952-1955

Four years of testing have shown that the Sebago variety is highly susceptible to decay caused by *F. sambucinum* f. 6, whereas the varieties Teton, Chippewa, Pontiac and Keswick may be regarded as equally or somewhat less susceptible than Sebago (Table 1). The relative susceptibility of varieties showing more resistance than Sebago is difficult to estimate because of the varied response shown in different comparative tests. Varieties showing fluctuating degrees of susceptibility and which may be regarded as liable to contract moderate to severe decay under epidemic field conditions include: Netted Gem, Early Gem, Chenango, Green Mountain, Kennebec, Canso, Katahdin, and McIntyre. A moderate to high degree of resistance was found in the varieties Essex, Houma, Cherokee, Irish Cobbler, Pungo, Menominee, Warba, Cayuga and Merrimack. In two years' testing of 21 numbered seedlings susceptibility to decay by *F. sambucinum* f.6 was noted in all stocks but the 1955 tests indicated that these seedlings were much less susceptible than Sebago (Table 2).

All varieties and seedlings tested for resistance to *F. sambucinum* f. 6 were also tested for resistance to *Fusarium coeruleum*. High susceptibility to decay caused by this organism was noted in the varieties White Cloud, Keswick, Warba, Cayuga and Pontiac, (Table 3). Varieties showing a lower and fluctuating degree of susceptibility included: Pungo, Chenango, Netted Gem, and McIntyre.

"Coeruleum" rot did not become readily established and progress of decay was slow in tubers of the varieties Essex, Ontario, Merrimack, Cherokee, Green Mountain, Snowflake, Early Gem, Kennebec and Menominee.

TABLE 1.—*The development of storage rot in named potato varieties following wounding and immersion in spore suspensions of Fusarium sambucinum f.6.*

Variety	Rot Index (Converted Averages)[1]			
	1952	1953	1954	1955
Sebago (control)	66.2	62.2	57.4	45.6
Teton	..	..	61.4	40.5
Chippewa	53.3	51.5	..	..
Early Gem	..	..	..	26.1
Pontiac	58.1	49.6	17.9	21.4
Keswick	47.8	56.3	45.8	19.9
Netted Gem	..	40.6	58.4	18.4
Chenango	..	..	47.0	17.5
Green Mountain	57.5	50.7	43.6	13.4
Kennebec	48.8	45.0	43.3	15.5
Canso	40.6	48.0	..	..
Katahdin	36.8	42.1	..	..
Ontario	..	..	38.9	15.3
White Cloud	..	..	35.5	15.1
Snowflake	..	..	..	14.4
McIntyre	73.6	32.6	28.9	11.1
Essex	..	36.8	8.7	12.1
Houma	29.2	32.1	..	..
Cherokee	..	..	29.4	8.9
Irish Cobbler	24.2	30.8	29.2	5.1
Pungo	..	..	18.9	13.0
Menominee	..	..	15.8	10.8
Warba	..	..	12.1	12.1
Cayuga	..	..	..	9.5
Merrimack	..	..	..	7.4
L.S.D. at P = 0.05	5.2	5.3	15.5	4.5

[1]Based on 4 replicates of 20 tubers each.

In the testing of the 21 numbered seedlings it was found in the 1955 comparisons that several stocks were equally or more susceptible to "coeruleum" decay than the Keswick control (Table 4).

DISCUSSION

In the evaluation of potato varieties for resistance to Fusarium storage decay a standardized method has been developed at Charlottetown for the purpose of demonstrating the hazards or advantages of growing certain varieties in areas where Fusarium decay is a serious economic problem. Boyd (*2*) tested over forty potato varieties for resistance to decay caused by *Fusarium coeruleum*. In estimating susceptibility he compared a standard laboratory injection method with a riddle-abrasion method in an attempt to secure proper susceptibility placement of varieties. His estimate was based on the correlation between physiological susceptibility of the tuber flesh and mechanical susceptibility involving liability to abrasion. With most of the varieties tested, there was general agreement between the results of each test, thus suggesting that skin resistance is,

TABLE 2.—*The development of storage rot in unnamed potato seedlings following wounding and immersion in spore suspensions of Fusarium sambucinum f.6.*

Variety	Rot Index (Converted Averages)[1] 1954	1955
Sebago	--	45.6 (control)
Teton	--	40.5
F4211	50.6	24.4
B962-32	50.5	21.9
F4963	42.5	21.0
B922-6	52.5	18.8
B926-9	43.4	17.8
F4970	32.4	16.9
F4412	46.3	15.5
B595-76	43.0	15.9
F4776	35.2	14.8
X792-88	38.5	13.4
F4991	42.4	13.9
F4772	45.3	12.7
F4768	34.2	11.1
B2368-4	34.8	11.6
B2368-11	39.3	10.1
B606-37	43.6	9.0
F4792	40.0	6.5
F4982	32.1	6.1
X792-94	35.2	6.1
F427	36.5	5.7
B355-35	34.1	4.4
L.S.D. at P = 0.05	5.3	4.5

[1]Based on 4 replicates of 20 tubers each.

in general, not a factor of great importance in susceptibility to dry rot. However, certain varieties showed wide differences in the results between the tests, and in most of these cases susceptibility shown by the abrasion method was lower.

In studies conducted at Charlottetown it is possible that, if liability to bruising had been correlated with susceptibility of the tuber flesh to dry-rot, some susceptible varieties might have assumed a higher or lower susceptibility rating. The method used, however, is regarded as accurate in demonstrating high resistance because ideal infection courts were established for the initiation of decay.

SUMMARY

Unnamed potato seedlings and new varieties have been assessed for resistance to Fusarium tuber decay through a comparison with established varieties of known susceptibility

Resistance to decay caused by *Fusarium sambucinum* f. 6 was determined by comparing varietal reaction with that of the susceptible Sebago, whereas the susceptible Keswick variety was used as a standard in the study of tuber resistance to *Fusarium coeruleum*.

TABLE 3.—*The development of storage rot in named potato varieties following wounding and immersion in spore suspensions of Fusarium coeruleum.*

Variety	Rot Index (Converted Averages)[1]			
	1952	1953	1954	1955
White Cloud	..	..	66.0	57.0
Keswick (control)	58.8	56.9	67.3	52.0
Warba	..	..	77.0	51.3
Cayuga	..	..	..	48.5
Pontiac	52.5	42.2	29.7	42.7
Pungo	..	..	16.0	45.7
Chenango	..	..	38.5	34.6
Netted Gem	..	48.4	19.3	31.2
Katahdin	47.7	42.7	..	..
Sebago	41.2	45.3	33.6	29.4
Canso	39.7	43.9	..	..
Teton	..	..	40.6	28.8
Houma	41.8	40.4	..	..
Chippewa	38.3	38.9	..	..
Irish Cobbler	36.1	38.1	38.0	29.4
McIntyre	25.2	41.6	78.6	17.7
Essex	..	31.5	34.6	25.2
Ontario	..	..	23.3	31.3
Merrimack	..	..	..	28.8
Green Mountain	31.3	33.7	16.0	28.2
Cherokee	..	..	13.1	31.1
Snowflake	..	..	..	27.0
Early Gem	..	..	..	21.3
Kennebec	27.1	28.5	2.3	13.5
Menominee	..	..	..	12.8
L.S.D. at P = 0.05	4.5	6.1	11.6	6.7

[1]Based on 4 replicates of 20 tubers each.

All tests were based on physiological susceptibility of the tuber flesh and it was found that reaction in established varieties was very similar to what might be expected from observations made in the commercial production of these stocks.

A study of tuber tissue reaction to *F. sambucinum* f. 6 showed that none of the stocks was more susceptible than Sebago. The varieties Sebago, Teton, Chippewa, Pontiac and Keswick proved quite susceptible to decay by this organism. Moderate to high resistance was demonstrated in Essex, Houma, Cherokee, Irish Cobbler, Pungo, Menominee, Warba, Cayuga and Merrimack.

High susceptibility to decay caused by *F. coeruleum* was shown in the varieties Keswick, Warba, White Cloud, Cayuga and Pontiac whereas tubers of Essex, Merrimack, Ontario, Green Mountain, Snowflake, Cherokee, Early Gem, Kennebec and Menominee showed moderate to high resistance.

TABLE 4.—*The development of storage rot in unnamed potato seedlings following wounding and immersion in spore suspensions of Fusarium coeruleum.*

Variety	Rot Index (Converted Averages)[1] 1954	1955
B962-32	20.1	66.5
B2368-11	35.0	53.9
X792-94	4.9	53.8
Keswick	--	52.0 (control)
Warba	--	51.3
B606-37	29.9	48.5
F427	14.6	47.0
X792-88	17.9	46.6
B2368-4	18.5	35.1
F4991	10.0	34.3
F4211	4.9	33.8
F4970	4.5	32.5
F4963	0.9	32.4
F4792	5.3	29.3
B926-9	9.0	27.9
F4982	2.5	27.4
F4776	10.6	22.7
B595-76	2.2	22.9
F4772	4.3	19.1
B355-35	5.0	17.7
B922-6	3.7	13.8
F4768	0	6.7
F4412	2.6	0
L.S.D. at P = 0.05	4.4	6.7

[1] Based on 4 replicates of 20 tubers each.

LITERATURE CITED

1. Ayers, G. W. and D. B. Robinson. 1954. An inoculation technique for the study of dry rot of potatoes. Amer. Potato Jour. 31 : 278-281.
2. Boyd, A. E. W. 1952. Dry-rot disease of the potato. VI. Varietal differences in tuber susceptibility obtained by injection and riddle-abrasion methods. Ann. Appl. Biol. 39 : 339-350.

THE EFFECT OF POTASH FERTILIZATION UPON POTATO CHIPPING QUALITY III. — CHIP COLOR[1]

TOM EASTWOOD AND JAMES WATTS[2]

INTRODUCTION

This paper will present some research data obtained in a study of the effects of potash fertilization upon potato chipping quality from 1951 to 1954 in soil culture. The N fertilization responses were reported previously (1), (2). No tables will be presented because of the limitation of space, there being a total of 139. Only the data concerning chip color will be given here; other data will follow in a subsequent paper in this Journal.

METHODS

The experimental methods used were presented previously (1).

EXPERIMENTAL RESULTS

1. 1951 Camp Potato Experiment

In general, chip color was good and was no doubt related to the good weather conditions. Use of a 160 pounds per acre application of muriate of potash improved chip color slightly compared with that produced by use of 120 pounds per acre. This slight improvement was apparent in the varieties Katahdin, Russet Rural and Nixon seedling.

2. 1952 Camp Potato Experiment

The chip color results showed a similar trend for the three series which received respectively 0, 9, and 18 weeks of previous cold storage treatment. (Each series showed the same trend.) The color was not very good, undoubtedly related to the very hot and dry season. There was no practical difference in the chip color of potatoes from plots receiving 80, 120 and 160 pounds of muriate of potash per acre.

There did not appear to be any interaction between either potash level, 80, 120, and 160 pounds per acre, and potato variety, Kennebec, Nixon Seedling, Russet Rural, and White Rural, or between potash level and nitrogen level, 40, 80, and 160 pounds per acre.

3. 1952 Penn State Experiment

The two sources of potash, muriate and sulfate, had no influence upon chip color.

Although the data were limited, it is apparent that the use of 225 pounds per acre of potash improved chip color slightly compared with that produced by using 150 pounds per acre.

A limited, but interesting, interaction developed between nitrogen level and potash source with respect to chip color. However, this response was only significant within the sulfate of potash plots, and it was only a trend within the muriate of potash-treated potatoes. The use of the

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lower level, 75 pounds per acre, of nitrogen fertilizer improved the chip color when the muriate of potash was employed. Conversely, the use of the higher application, 150 pounds per acre, of nitrogen improved the chip color when the sulfate of potash was used.

4. 1953 New Jersey Experiment

Poor chip color was produced by all the potatoes. Only the initial fry produced an appreciable amount of chips with an acceptable color. No doubt the dry and hot weather, especially the hot weather, were in part responsible for this poor chip color quality. The use of muriate of potash improved the chip color slightly compared with that produced by the use of the sulfate of potash.

Although a number of significant interactions developed in the analyses of the data, the experimental design in the field did not permit too much interpretation. Potato variety (using Cobbler, Chippewa, and Katahdin) had no influence upon the direct potash source effect upon chip color. A weak interaction seemed to develop between potash source and irrigation. This was noted chiefly in that the best chip color came from the potatoes from plots that received the muriate of potash in the non-irrigated areas.

5. 1954 New Jersey Experiment

Only fair chip color was obtained. A slight improvement in chip color was noted from the use of the muriate of potash as compared with the use of the sulfate of potash.

Neither potato variety (Cobbler, Chippewa, and Katahdin) nor farm location (three farms) influenced the direct response of the potash source upon chip color.

6. 1954 Penn State Experiment

The direct effect of the potash level as KCl, at 80-160-0, 80-160-80, 80-160-160, and 80-160-240 pounds per acre, upon chip color was unclear and it was affected by several interactions with other factors. Although no interaction developed between potash level and location (for), the greatest changes in chip color were related to location rather than to potash level in the fertilization. The trend toward progressively better chip color as the amount of potash was increased at the Potter location was of interest. The potash availability in this soil was low, and the use of any potash in the fertilizer showed definite responses in plant growth and potato yields.

Discussion and Summary

1. The use of higher levels of potash tended to improve chip color slightly, but it was of doubtful practical value.

2. Some interactions between potash level and the other experimental variables affected the chip color: (a) potato variety caused a variable effect upon the influence of potash level on chip color, Katahdin seeming to be improved more in chip color than Russet Rural with the higher applications of potash (but this may have been further altered by the source of potash); (b) nitrogen level and potash level did not appear to interact here; (c) farm location did not significantly interact with potash level, but it caused a greater effect than did potash level; (d) potash source did not react with potash level; (e) weather conditions seemed to make a

great difference upon the chip color quality; (f) conditions which reduced yields of potatoes, such as limited rainfall coupled with cool weather, seemed to produce better chip color, apparently when the crop grew slowly rather than rapidly or when the latter portion of the season was conducive to slow growth, chip color was better. Cultural conditions also may be a factor because in the 1952 Camp Potato Experiment wherein the 120 pounds per acre of potash produced the lowest yields it also produced the best chip color, and in the 1953 Experiment in New Jersey, the muriate of potash plots, with no irrigation, produced the lowest yields and yielded the best chip color.

3. Although the difference was not significant, the muriate of potash, in general, produced a slightly better chip color than did the sulfate of potash.

4. Interesting trends between potash source and the other experimental variables were present: (a) a variable and indecisive reaction was caused by potato variety, (b) irrigation likewise caused an indefinite effect upon the direct response of the potash source upon chip color, (c) the amount of nitrogen seemed to effect the influence of the potash source; (d) farm location did not appear to interact with potash source, but rather directly changed the chip color more than did potash source; and (e) weather conditions changed chip color pronouncedly.

Literature Cited

1. Eastwood, Tom and James Watts. 1956. The effect of nitrogen fertilization upon potato chipping quality. I. Chip color. Amer. Potato Jour. 33: 187-189.
2. ———— and ————. 1956. The effect of nitrogen fertilization upon potato chipping quality. II. Specific gravity. Amer Potato Jour. 33: 211-213.

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1. 1951 and 1952 Camp Potato Experiments: E. L. Nixon, Agricultural Advisor, Pa. Potato Growers Co-op Assn., Coudersport, Pa., and S. D. Gray, Manager Northeast Branch, American Potash Institute, Washington, D. C.
2. 1952 Penn State Experiment: J. S. Cobb, Agronomy Dept., The Pennsylvania State University, University Park, Pa.
3. 1953 and 1954 New Jersey Experiments: J. C. Campbell, Department of Plant Pathology, New Jersey Agricultural Experiment Station, New Brunswick, N. J; and Graham Campbell and Paul Mott, Chamberlin and Barclay, Cranbury, N. J.
4. 1954 Penn State Fertilizer Experiment: F. G. Merkel and Herman Thimm, Agronomy Department, The Pennsylvania State University, University Park, Pa.

b. Wise Horticultural Research Staff
1. Experimental Data: Harry Boyer, Richard Wolfe, Harold Rhone, Edward Schecterly, Mason Hoida, and Wilbur Shoemaker.
2. Statistical Analysis: Harry Boyer, Richard Wolfe, Adele McHenry, and Edward Hoover.

NEWS AND REVIEWS

CALL FOR TITLES OF PAPERS

The next annual meeting of the Potato Association of America will be held in conjunction with the American Phytopathological Society on December 6, 7, and 8 at the Netherland Plaza Hotel, Cincinnati 1, Ohio.

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The Housewife may not realize it but that "better tasting" potato is one that was sprayed with TRIANGLE BRAND COPPER SULPHATE. Spraying with Triangle Brand Copper Sulphate in Bordeaux Mixture to control blight is a safe and economical way to insure a good crop. It gives a better yield of No. 1's, with better storage expectancy, and helps the potato retain its NATURAL FLAVOR. This means increased consumer acceptance and greater profit to the grower. Despite the claims made for organic fungicides, experienced and successful growers still prefer time-tested COPPER SULPHATE for the control of early and late blight. Try it on your crop and see the difference.

CONTROL POND SCUM AND ALGAE in farm waters with TRIANGLE BRAND COPPER SULPHATE.

FENCE POST treatment with TRIANGLE BRAND COPPER SULPHATE prevents decay and termite damage.

Send today for information on these important uses of copper sulphate.

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Is poor quality killing the *Potato Market?*

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COPPER Improves QUALITY
QUALITY Increases PROFIT

Practical experience through years of usage of **TRI-BASIC COPPER** and comparison with the newer organic fungicides has proven **TRI-BASIC** to be outstanding in **UPGRADING POTATO PRODUCTION** by providing

- ★ LESS TUBER ROT.
- ★ FEWER PICK OUTS.
- ★ BETTER SHIPPING QUALITY.
- ★ HIGHER SOLIDS CONTENT.
- ★ FEWER WATERY POTATOES.
- ★ BETTER CHIPPING STOCK.
- ★ INCREASED STORAGE ABILITY.

TENNESSEE **TRI-BASIC** COPPER SULFATE

THAT'S NOT ALL—LOOK at these other **ADVANTAGES** in using a **COPPER FUNGICIDE.**

No residue tolerance restrictions.

Longer application internal—provides added days protection while conserving money, chemicals, labor, time, machinery depreciation, soil compaction and mechanical injury to vines and tubers. Easy to apply as spray or dust.

Provides nutritional element COPPER—essential to plant growth and production.

MR. GROWER—INSIST ON TRI-BASIC COPPER—IT IS PLENTIFUL AND ECONOMICAL. Don't be misled—Don't take chances. INSURE SUCCESS THROUGH THE USE OF TENNESSEE'S TRI-BASIC COPPER.

See your dealer or write

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